Section 5.2

Mission Operations Center

Spacecraft I&T

Flight Dynamics Facility

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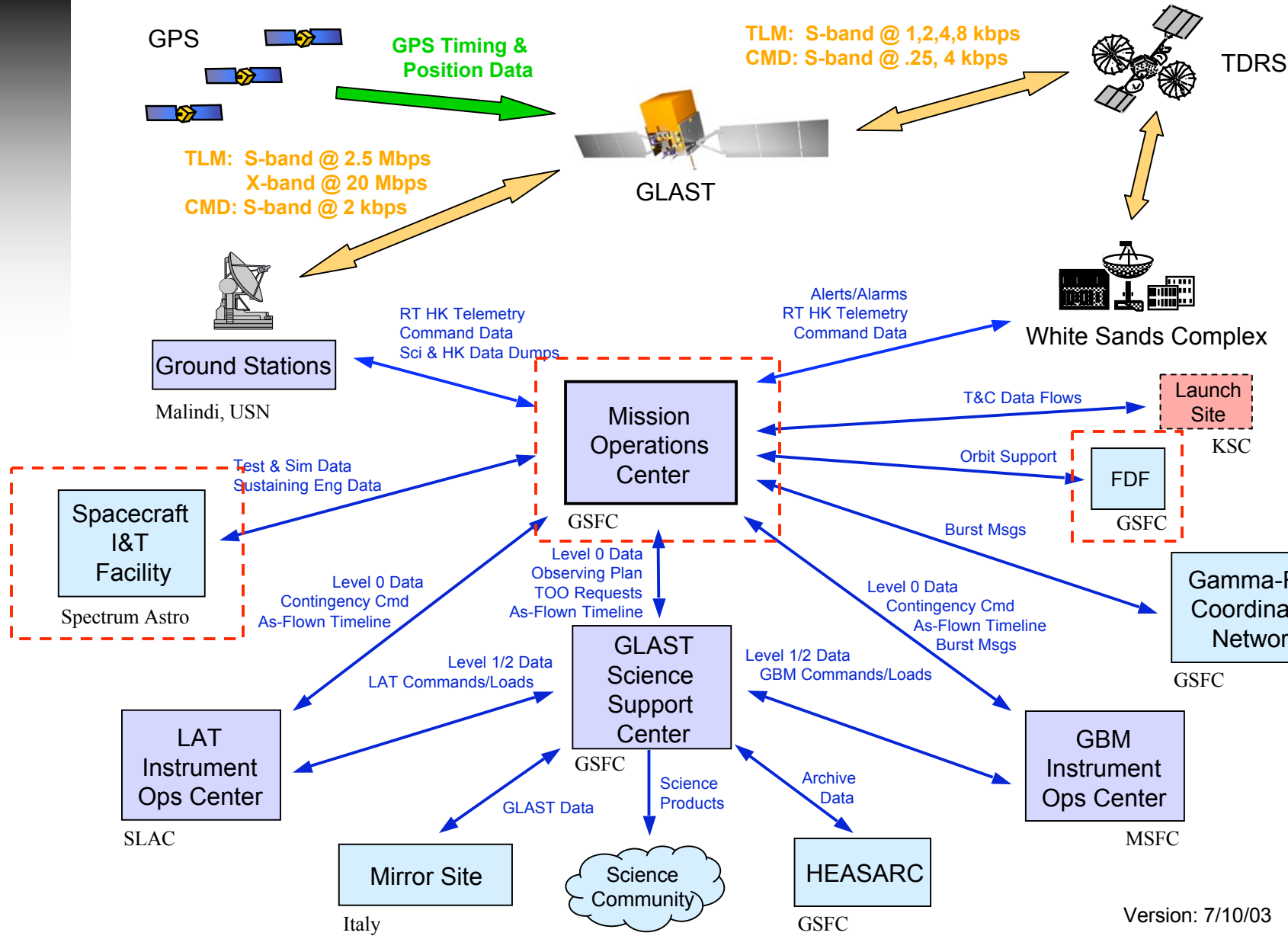
MOC Manager

Outline

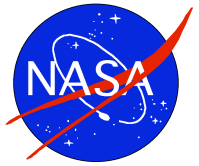
- ***MOC***
  - *Reference Architecture*
  - *Key Requirements*
  - *Organization & Staffing*
  - *Development & Test Approach*
  - *Management Plan*
  - *Schedule*
- ***Spacecraft I&T***
  - *Key Requirements*
- ***Flight Dynamics Facility***
  - *Key Requirements*

Ground System Architecture



Version: 7/10/03

MOC Key Requirements



Planning & Scheduling

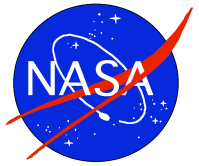
- ***Receive science observation timeline, ToO Orders from GSSC***
- ***Schedule GN & SN resources for RF comm with Observatory***
- ***Generate orbit products for planning tools and for GN/SN acquisition***
- ***Generate integrated mission timeline based on science observation timeline***
- ***Generate command loads (ATS, RTS loads) based on integrated mission timeline***
- ***Receive FSW loads from Spacecraft Bus Team & IOCs, schedule uplink***
- ***Receive Instrument command requests from GSSC/IOCs, schedule uplink***
- ***Provide ability to respond to ToO Orders within 4 hours***
  - *Generate ToO command, schedule TDRSS, uplink command*

MOC Key Requirements (cont.)

Telemetry & Command Processing

- ***Provide sole interface between ground system elements and space-ground comm links***
  - *Interface with TDRSS DAS & WDISC, Ground Stations*
- ***Generate and uplink all commands to the Observatory***
  - *R/T commands, ATS & RTS Loads, Tables, FSW Loads*
  - *Verify commands against constraints prior to uplink*
  - *Support CCSDS compliant commands, COP-1 verification protocol*
- ***Receive, process and archive Observatory telemetry***
  - *Support CCSDS compliant Telemetry*
  - *Receive R/T Telemetry from Ground Stations and TDRSS*
  - *Receive Recorded Telemetry from Ground Stations post-pass*
  - *Archive all CCSDS frames for Life of Mission*
  - *Decommutate and process housekeeping Telemetry*
  - *Provide R/T telemetry displays for local and remote users*
  - *Monitor spacecraft & instrument housekeeping TLM for health & safety*
  - *Receive and process S/C & instrument onboard processor memory dump data*

MOC Key Requirements (cont.)



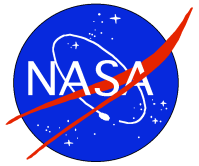
Alert Handling

- ***Receive, process & log Burst Alerts, forward to GCN front-end (BAP) within .5 second***
- ***Receive, process & log Autonomous Re-points, notify science ops personnel***
- ***Receive, process & log S/C & instrument Alarm Messages, page ops personnel***

Offline Analysis

- ***Perform trending & analysis of key Observatory housekeeping data***
- ***Monitor execution of science timeline, generate As-Flown Timeline as record of actual observations executed onboard***
- ***Provide access for remote users to Telemetry, Trending data & other MOC products***
  - *Timelines, contact schedules, command logs, event logs, orbit data, anomaly reports, etc.*

MOC Key Requirements (cont.)



Data Processing

- ***Generate Level 0 telemetry data sets & deliver to GSSC, IOCs within 4 hours of receipt from Ground Stations***
  - *Generate time-ordered, duplicate-removed packet files on per-pass basis*
  - *Archive Level 0 data sets for minimum of 7 days*
- ***Generate telemetry frame quality statistics & log missing frames***

Automation

- ***Provide capability to support single 8x5 staffed shift and operate autonomously whenever not staffed***
- ***Provide automated pass execution (including SSR dumping)***
- ***Provide automated data processing and product delivery***
- ***Provide automated telemetry monitoring***
- ***Monitor ground systems, data product generation***
- ***Provide automated alarm detection and paging of on-call FOT for Observatory or ground system anomaly***

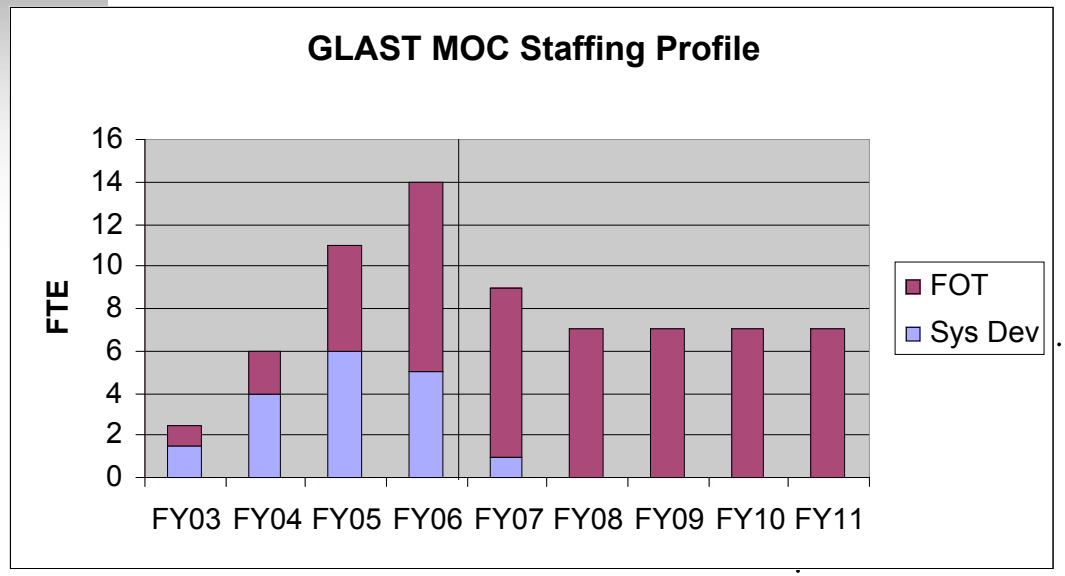
MOC Key Requirements (cont.)

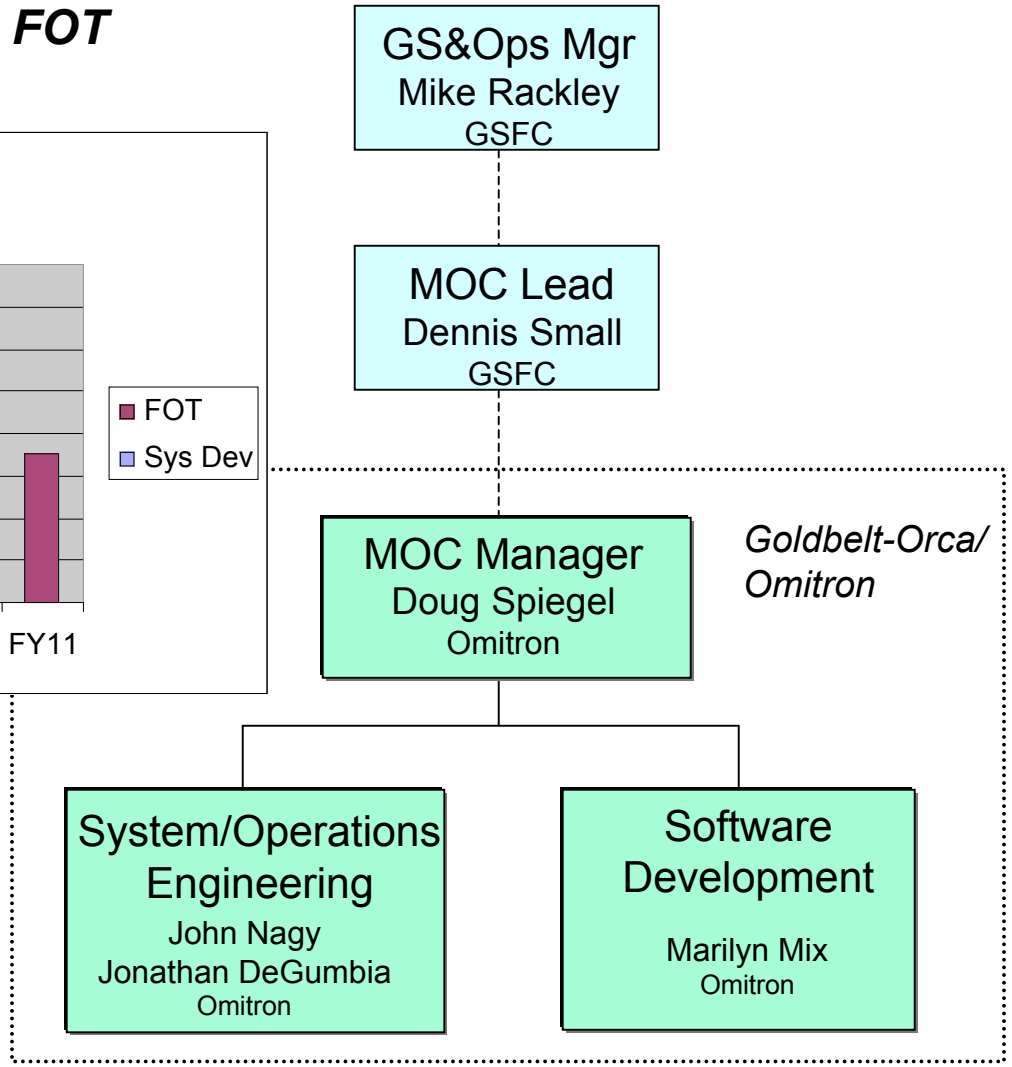
Support

- ***Support anomaly investigation & resolution***
  - *Provide capability to generate & track anomaly reports*
  - *Provide access to TLM archive, CMD logs, event logs and other pertinent MOC products*
- ***Support sustaining engineering of Observatory & Ground System***
  - *Receive FSW loads, table loads from S/C & Instrument Teams, uplink to Observatory*
  - *Maintain MOC H/W & S/W systems*
  - *Maintain CM of TLM & CMD Database, PROCs, display pages, configuration monitors, MOC documentation*

MOC Organization

- ***Goldbelt/Orca & Omitron teamed to provide MOC system, FOT***





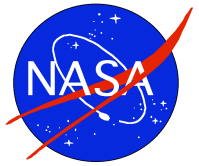
MOC Development Approach

- ***Based on Swift MOC model, leverage Swift system reuse and staff experience***
- ***Defined in MOC Development Plan***
- ***Develop Operations Concept, detailed MOC Requirements (level 4)***
  - *Flow down from GSRD, establish traceability*
- ***Define architecture, interface protocols, develop system design***
  - *Perform trade studies as needed to assess best fit of functionality, cost, ease of use, ease of maintenance*
- ***Package-based software development***
  - *Integrate COTS/GOTS packages, configure & tailor where necessary for GLAST needs*
  - *Augment with custom s/w to meet GLAST specific requirements*
- ***Incremental build & test approach***
  - *Phasing of functionality driven by needs of ground system test program*
  - *Perform detailed design, coding, unit test, system test and acceptance testing for each release*

MOC Element-Level Testing

- ***Requirements and scenario based testing***
- ***Develop MOC requirements verification traceability matrix to track coverage of all requirements***
- ***Develop test cases to verify functionality, performance of each MOC component, proper generation of all required products***
- ***Develop system level test cases to verify system threads and end to end functionality***
- ***Perform long duration test and negative testing to ensure system reliability, robustness***
- ***Perform interface tests with SN, GN, GSSC, IOCs, BAP/GCN, S/C***
- ***Test sources: Simulators (PSS, CTS, MTS, Hotbench), recorded S/C data from I&T, Observatory testing in I&T***
- ***Documented in MOC Test Plan***

MOC Management Plan



- ***Project Management***
  - *Direct participation in GOWG, GS/Ops staff meetings*
  - *Develop & maintain detailed MOC development schedule including tasks for system engineering, software development, testing, ops preparation*
  - *Provide monthly status report to GS/Ops Mgr & MOC Lead, identify issues/concerns and any risk items*
  - *Track monthly cost/schedule against plan, report variances*
  - *Track internal issues & action items to closure*

MOC Management Plan (cont.)

- ***Configuration Management***
  - *Support Project- and Ground System-level CCBs as needed*
  - *All MOC software, config files, Project DB, PROCs, pages, configmons, procedures controlled in CM repository using CVS tool*
  - *Installation of MOC releases from CM repository, ability to revert to prior version if needed*
  - *Key MOC documents controlled via Project or GS CCB (as appropriate)*
    - *MOC Level 4 Requirements to be controlled by GS CCB*

MOC Management Plan (cont.)

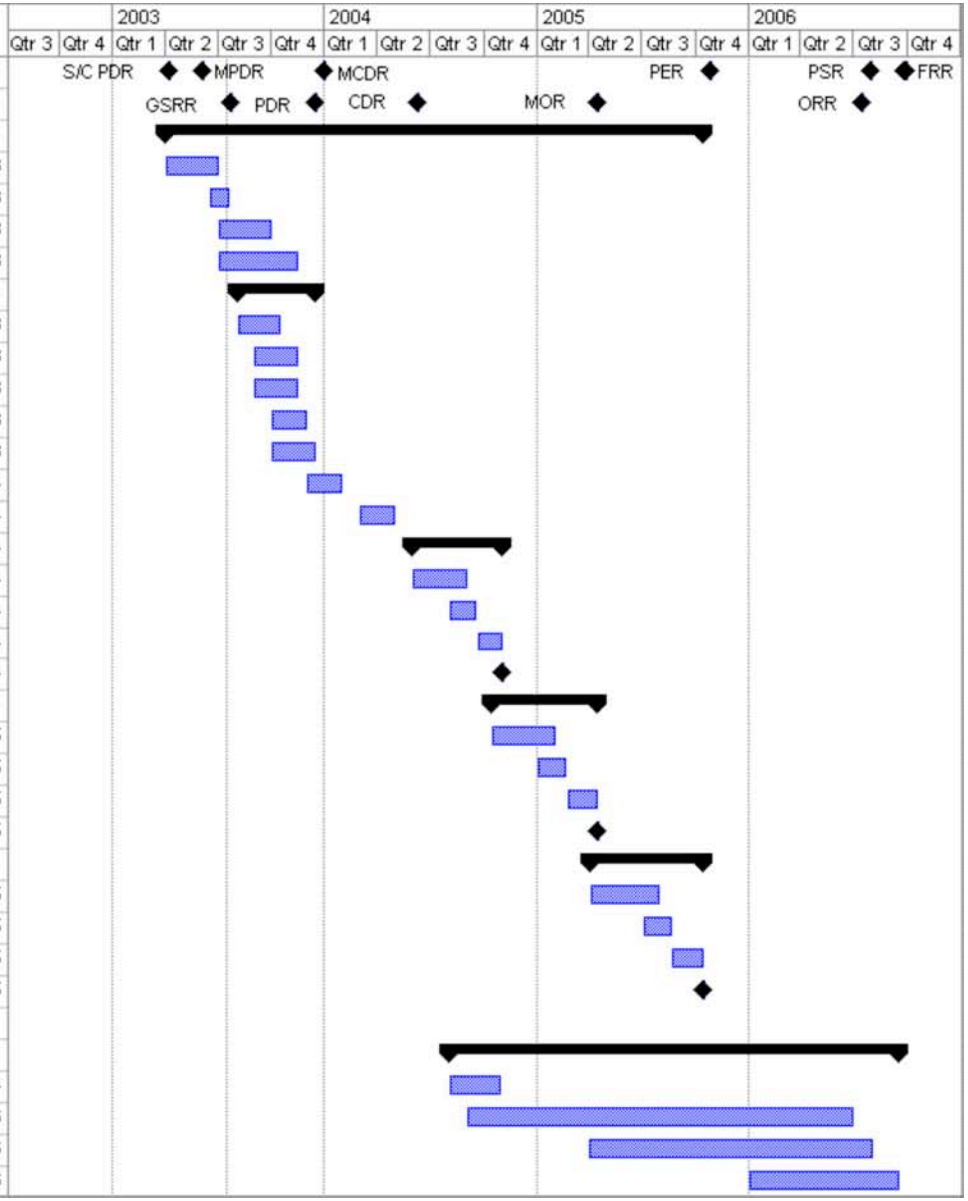
- ***Quality Assurance***
  - *Walkthroughs held for all MOC requirements, component designs, code & unit tests, system test cases*
  - *Peer Reviews held for MOC system design (prior to PDR & CDR) and operations plans (prior to MOR)*
  - *Discrepancy Reports generated & maintained in online repository (SERS), tracked to closure*
  - *All changes to controlled products reviewed; any requirements/scope or interface changes elevated to CCB for approval*
  - *Regression testing performed to verify changes have not adversely affected existing functionality/performance*

MOC Documents

Document	Preliminary		Baseline		CCB	Comments
	Milestone	Date	Milestone	Date		
Operations Concept Document	-	-	SRR+1 mo.	8/22/03	Project	Rev A (Original baselined Mar'02)
Development Plan	SRR	7/15/03	SRR+3 mos.	10/20/03	Internal	
MOC System Requirements	PDR	11/15/03	CDR-2 mos.	3/31/04	GS	
DB Format & Naming Convention	SRR	7/15/03	MCDR-1 mo.	12/15/03	GS	
Proc Style Guide	PDR	12/1/03	CDR	6/1/04	Internal	
Design Spec	PDR	11/30/03	CDR	7/1/04	Internal	Revision post-CDR for RFAs
CM Plan		1/31/04	CDR	6/1/04	Internal	
MOC Test Plan	CDR-2 mos.	4/30/04	CDR+2 mos.	7/31/04	Internal	
Security Plan	PDR	12/15/03	CDR	6/30/04	GS	Revision post-CDR for RFAs
MOC-CGS ICD	PDR	12/15/03	CDR-1 mo.	5/15/04	GS	
MOC-FDF ICD	PDR	12/15/03	CDR-1 mo.	5/15/04	GS	
MOC-GSSC ICD	PDR	12/15/03	CDR-1 mo.	5/15/04	GS	
MOC-LAT ICD	PDR	12/15/03	CDR-1 mo.	5/15/04	GS	
MOC-GBM ICD	PDR	12/15/03	CDR-1 mo.	5/15/04	GS	
Mission Ops Readiness Plan	MOR-6mos.	10/31/04	MOR	4/15/05	GS	
Training & Certification Plan		6/30/05	ORR-8 mos.	11/30/05	Internal	
Sustaining Engineering Plan	.	12/15/05	ORR-2 mos.	5/31/06	Internal	
Flight Ops Manual	MOR-1 mo	3/15/05	ORR-1 mo.	6/15/06	Internal	
Ops Agreements					GS	As Needed

MOC Schedule

ID	Task Name	Duration	Start	Finish
1	**Project Milestones**	**910 days**	**Tue 4/8/03**	**Sat 9/30/06**
9	**Ground System Milestones**	**779 days**	**Tue 7/22/03**	**Fri 7/14/06**
15	**MOC Development**	**664 days**	**Tue 4/1/03**	**Fri 10/14/05**
16	Ops Concept Document	65 days	Tue 4/1/03	Mon 6/30/03
17	MOC Development Plan	25 days	Mon 6/16/03	Fri 7/18/03
18	MOC System Requirements	66 days	Tue 7/1/03	Tue 9/30/03
19	System Design	99 days	Tue 7/1/03	Fri 11/14/03
20	**ICDs**	**96 days**	**Mon 8/4/03**	**Mon 12/15/03**
21	MOC - GSSC ICD	53 days	Mon 8/4/03	Wed 10/15/03
22	MOC - GIOC ICD	55 days	Mon 9/1/03	Fri 11/14/03
23	MOC - LIOC ICD	55 days	Mon 9/1/03	Fri 11/14/03
24	MOC - FDF ICD	43 days	Wed 10/1/03	Fri 11/28/03
25	MOC - Comm Grnd Stn ICD	54 days	Wed 10/1/03	Mon 12/15/03
26	CM Plan	45 days	Mon 12/1/03	Fri 1/30/04
27	Test Plan	45 days	Mon 3/1/04	Fri 4/30/04
28	**Release 1**	**110 days**	**Tue 6/1/04**	**Mon 11/1/04**
29	Design / Code / Unit Test	66 days	Tue 6/1/04	Tue 8/31/04
30	Integration	35 days	Mon 8/2/04	Fri 9/17/04
31	System Test	31 days	Mon 9/20/04	Mon 11/1/04
32	R1 Delivery	1 day	Mon 11/1/04	Mon 11/1/04
33	**Release 2**	**131 days**	**Fri 10/15/04**	**Fri 4/15/05**
34	Design / Code / Unit Test	77 days	Fri 10/15/04	Mon 1/31/05
35	Integration	35 days	Mon 1/3/05	Fri 2/18/05
36	System Test	39 days	Mon 2/21/05	Thu 4/14/05
37	R2 Delivery	1 day	Fri 4/15/05	Fri 4/15/05
38	**Release 3**	**140 days**	**Mon 4/4/05**	**Fri 10/14/05**
39	Design / Code / Unit Test	85 days	Mon 4/4/05	Fri 7/29/05
40	Integration	35 days	Mon 7/4/05	Fri 8/19/05
41	System Test	40 days	Mon 8/22/05	Fri 10/14/05
42	R3 Delivery	1 day	Fri 10/14/05	Fri 10/14/05
43				
44	**Operations Prep**	**555 days**	**Mon 8/2/04**	**Fri 9/15/06**
45	Mission Ops Readiness Plan	65 days	Mon 8/2/04	Fri 10/29/04
46	MOC & Ground System Testing	478 days	Wed 9/1/04	Fri 6/30/06
47	Ops Product Dev & Validation	348 days	Fri 4/1/05	Tue 8/1/06
48	Mission Simulations & Rehearsals	185 days	Mon 1/2/06	Fri 9/15/06



MOC Release Plan

- ***Release 1 (Nov '04) – GRT#1, 2***
  - *TLM & CMD Processing*
  - *Level 0 TLM Processing*
  - *Integrated Timeline and Command Load Generation*
- ***Release 2 (Apr '05) – GRT#3, 4***
  - *Alert Handling*
  - *Level 0 Product Distribution*
  - *Timeline Monitoring*
  - *Flight Dynamics*
- ***Release 3 (Oct '05) – GRT# 5***
  - *Contact Scheduling*
  - *System Automation*
  - *System Monitoring & Paging*
  - *Trending & Analysis*

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  - *Organization & Staffing*
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  - *Management Plan*
  - *Schedule*
- ***Spacecraft I&T***
  - *Key Requirements*
- ***Flight Dynamics Facility***
  - *Key Requirements*

Spacecraft I&T Key Requirements

Spacecraft bus and Observatory level I&T performed at Spectrum Astro's facility in Gilbert, AZ, under direction of Spectrum I&T Mgr

- ***Provide access to Hotbench from the MOC @ GSFC for telemetry & command testing***
- ***Accommodate MOC system installation in I&T Facility for testing with the Observatory & Hotbench***
- ***Accommodate MOC FOT personnel in I&T Facility***
  - *Provide physical space in facility*
  - *Integrate FOT into I&T program*
- ***Provide access to Observatory from the MOC @ GSFC for ground system testing***
- ***Provide Observatory TLM & CMD Databases to the MOC (ITOS format)***
- ***Accommodate ground station RF test equipment for RF compat testing***

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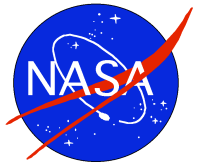

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FDF Key Requirements

FDF institutional services provided via Mission Operations and Mission Services (MOMS) Project Service Level Agreement (PSLA)

- ***Receive NORAD Two-Line Elements (TLE), post to OIG web site***
- ***Receive GPS data from MOC, perform independent orbit determination***
  - *During L&EO, for confirmation of MOC-generated solutions*
- ***Provide TDRSS Differenced One-Way Doppler (DOWD) orbit determination support***
- ***Provide orbit products to MOC***
- ***Provide orbit analysis support for pre-launch, L&EO, and on-orbit operations phases***
- ***Provide Delta ELV launch support***
  - *Receive pre-launch trajectories from Boeing, provide predicted insertion vectors to MOC*
  - *Receive & process real-time Delta inertial guidance data during powered flight*
  - *Provide post-separation orbit insertion vector to MOC*